Sounak Mandal
19EC10088
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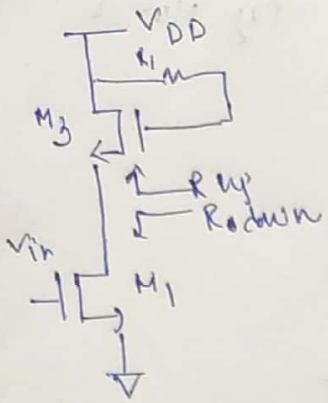
2. For differential mode the half circuit is



$$R_{up} = \frac{r_{oy} + R_1}{1 + g_{my} r_{oy}}$$

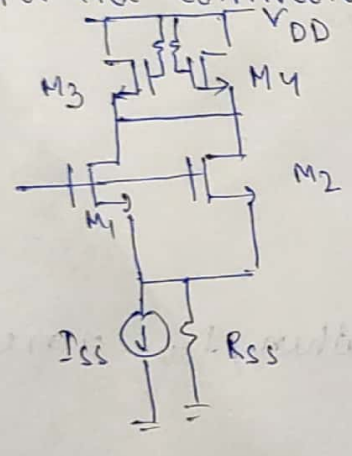
$$R_{odown} = r_{ox}$$

$$R_{out} = r_{ox} \parallel \frac{r_{oy} + R_1}{1 + g_{my} r_{oy}}$$

$$G_m = g_{m1} = g_{mx}$$

$$A_{dm} = -g_{mx} \left(r_{ox} \parallel \frac{r_{oy} + R_1}{1 + g_{my} r_{oy}} \right)$$

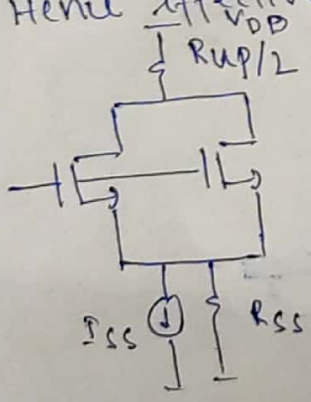
For the common mode circuit we use virtual short



For each of M_3 and M_4 looking up is

$$\frac{r_{oy} + R_1}{1 + g_{my} r_{oy}} = R_{up}$$

Hence effective circuit is



Both R_{up} come in parallel
The transistors come in parallel with $G_m = \frac{2g_{mx}}{1 + 2g_{mx}R_{ss}}$

$$A_{cm} = -\frac{R_{up}/2}{\frac{1}{G_m} + \cdots}$$

$$A_{cm} = -G_m R_{out}$$

$$= -\frac{2g_{mx}}{1 + 2g_{mx}R_{ss}} \left(\frac{R_{up}}{2} \parallel \frac{r_{ox}}{2} \right)$$

$$A_{cm} = -\frac{2g_{mx}}{1+2g_{mx}R_{ss}} \frac{1}{2}(R_{up} \parallel r_{ox})$$

$$= -\frac{g_{mx}\left(r_{ox} \parallel \frac{r_{oy}+R_1}{1+g_{my}r_{oy}}\right)}{1+2g_{mx}R_{ss}}$$

$$= -\frac{r_{ox} \parallel \frac{r_{oy}+R_1}{1+g_{my}r_{oy}}}{\frac{1}{g_{mx}} + 2R_{ss}}$$